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Singh, S. P., Molina, A., Urrea, C. A. and Gutiérrez, J. A. 1993. **Use of interracial hybridization in breeding the race Durango common bean.** Can. J. Plant Sci. **73**: 785–793. Recently, interracial hybridization was used successfully in breeding common bean (*Phaseolus vulgaris* L.), but its use has not been adequately documented. Approximately 125 lines with medium-sized seed were selected in the first cycle, mostly from race Durango × race Mesoamerica (both from the Middle American domestication center) single- and multiple-cross populations, for disease resistance and race Durango characteristics. Fifteen of these improved lines, three race Durango control cultivars, and one control cultivar each from races Jalisco and Mesoamerica were evaluated for 3 yr (1989-1991) at three locations in Colombia. A randomized complete block design with three replications was used. Lines were developed using visual mass selection for seed yield and/or resistance to diseases in F_2 and F_3, followed by single plant harvests in F_4 or F_5 and seed increases in F_6 or F_7. Lines resistant to bean common mosaic virus and possessing other desirable traits were yield-tested in F_7 or F_8. All but two lines outyielded Alteño and Flor de Mayo, the highest yielding control cultivars from races Durango and Jalisco, respectively. Two lines also outyielded Carioca, the race Mesoamerica control cultivar. Improved lines tended to possess higher yield per day. All lines were resistant to bean common mosaic virus and most lines also carried a high level of resistance to anthracnose. Plant, seed, and maturity characteristics of most improved lines were similar to those of race Durango control cultivars. These results support the use of interracial hybridization in improving race Durango common bean.

Key words: Common bean, *Phaseolus vulgaris*, race Durango, interracial populations, seed yield, disease resistance

Singh, S. P., Molina, A., Urrea, C. A. et Gutiérrez, J. A. 1993. **Utilisation de l'hybridation inter-races dans l'amélioration du haricot Durango.** Can. J. Plant Sci. **73**: 785–793. Ces dernières années, les croisements inter-races ont été utilisés avec succès pour l'amélioration du haricot (*Phaseolus vulgaris* L.), mais son utilisation n'est pas suffisamment documentée. Quelque 125 lignées à grains moyens ont été sélectionnés dans le premier cycle pour la résistance aux maladies et pour les caractères du type Durango. La plupart résultaient de croisements simples ou multiples entre la race Durango et la race Mesoamerica, toutes deux issues du centre de domestication mesoaméricain. Quinze des lignées améliorées, trois cultivars témoins de race Durango et un cultivar des races Jalisco et Mesoamerica ont été évalués pendant trois ans (1989-1991) à trois emplacements en Colombie, selon un dispositif expérimental en blocs aléatoires complets à trois répétitions. Les lignées étaient le résultat de sélection massale visuelle pour le rendement grainier et/ou pour la résistance aux maladies en F_2 et en F_3, suivi de sélection généalogique en F_4 ou F_5 et de multiplication des semences en F_6 ou F_7. Les lignées résistantes au virus de la mosaïque commune et possédant d'autres caractères agronomiques souhaitables subissaient des tests de rendement en F_7 ou F_8. Toutes les lignées sauf deux surpassaient en rendement Alteno et Flor de Mayo, respectivement, les deux variétés témoins les plus productives des races Durango et Jalisco. En outre, deux lignées surpassaient Carioca, le cultivar témoin de la race Mesoamérica. Les lignées améliorées fournissaient en général un taux de rendement par jour plus élevé. Toutes les lignées étaient résistantes au virus de la mosaïque commune et en outre la plupart démontrait un niveau élevé de résistance à l'anthracnose. Les caractères de la plante, de la graine, ainsi que le niveau de précosité, de la plupart des lignées améliorées étaient semblables à ceux des cultivars témoins de la race Durango. Ces résultats viennent conforter la valeur de l'hybridation interraces pour l'amélioration du haricot Durango.

Mots clés: Haricot, *Phaseolus vulgaris*, race Durango, populations interraces, rendement grainier, résistance aux maladies

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Morphological, molecular, agronomic, and adaptation traits were used to study and characterize races of common bean (*Phaseolus vulgaris* L.). Three races from the Middle American domestication centers (Durango, Jalisco, and Mesoamerica) and three races from Andean South America (Chile, Nueva Granada, and Peru) have been described (Singh et al. 1991a). Race Durango is characterized by common bean germplasm that is indeterminate, weak-stemmed, and prostrate, and has growth habit III (Singh 1982a). This germplasm possesses medium-sized seed (25-40 g/100-seed weight) of often rhombohedric shape. Earliness, drought tolerance, high harvest index, and resistance to anthracnose, bean golden mosaic virus, cucumber mosaic virus, and bean common mosaic virus (recessive gene resistance) are found in some accessions of this race. Popular market classes, seed types, and cultivars belonging to this race include pinto, great northern, pink, red Mexican, 'bayo' (beige), 'ojo de cabra' (cream striped), and 'negro San Luis' (shiny black). Over 1.5 million ha of cultivars of this race are grown annually in the semi-arid highlands of Mexico, mid-western and northwestern United States, Canada, Chile, France, Greece, Italy, Turkey, Iran, and other parts of the world. The availability of cultivars with upright plant type, insensitivity to long photoperiod, tolerance to high temperature (especially during flowering), and resistance to rust caused by *Uromyces appendiculatus* (Pers.) Unger var. *appendiculatus* and root rots caused by a group of soil-borne fungi, among other factors, would further help increase productivity and hectarage sown to this group of cultivars worldwide. In order to achieve tangible and long-lasting selection gains, desirable genes for most of these and other traits must be transferred from other races and gene pools, wild populations, and related species of *P. vulgaris*.

Considerable breeding, largely involving intraracial hybridization, has been carried out, especially in the United States, for disease resistance in great northern, pinto, pink, and red Mexican bean types. Lack of knowledge of combining ability among races; difficulties with recovery of recombinant genotypes (especially from single-cross interracial populations) with desirable seed (size, color, shape, etc.), plant, and adaptation characteristics; occurrence of hybrid incompatibility (Shii et al. 1980; Singh and Gutiérrez 1984; Gepts and Bliss 1985; Sprecher and Khairallah 1989; Vieira et al. 1989; Singh and Molina 1991); segregation distortion (Koenig and Gepts 1989); and use of conservative breeding methods have often limited interracial hybridization in common bean. More recently, some interracial crosses were made to improve biological nitrogen fixation (Bliss 1985), develop pinto and great northern cultivars with upright plant type (Kelly and Adams 1987), increase seed yield (Singh et al. 1989), and increase resistance to bean golden mosaic virus (Morales and Singh 1993).

Studies at CIAT reported that a relatively high frequency of accessions belonging to the Middle American races Durango and Jalisco possessed positive general combining ability for seed yield (Nienhuis and Singh 1986, 1988a; Singh et al. 1992b). Germplasm from these races has been used on a limited basis to improve yielding ability of small-seeded cultivars of the tropical race Mesoamerica (Singh and Gutiérrez 1990; Singh et al. 1989, 1991b, 1992c).

Breeding for race Durango cultivars using interracial hybridization was begun at CIAT in 1981-1982 and the first selection cycle was completed by 1988. Popular landraces and cultivars of the Mexican highland race Durango were hybridized with small-seeded, lowland tropical germplasm belonging to the race Mesoamerica. A few medium-seeded parents of race Jalisco and large-seeded parents of Andean races Chile and Nueva Granada were also used. The characteristics of a few representative parents used in hybridization are given in Table 1. The primary objective of these crosses was to incorporate resistance to bean common mosaic virus (BCMV), conditioned by the hypersensitive dominant *I* gene, and anthracnose (caused by *Colletotrichum lindemuthianum* Sacc. & Magn.) Scrib. Donor parents resistant to common bacterial blight (caused by *Xanthomonas campestris* pv. *phaseoli* (Smith) Dye) and angular leaf spot (caused by *Phaeoisariopsis griseola* (Sacc.) Ferr.) were also included in some, but not all, populations. Furthermore, attempts were made to incorporate adaptation to tropical environments and improve yielding ability. At first, single crosses were made. Because of difficulties in recovering desirable seed characteristics from such crosses, multiple parent crosses were then made (Table 2). The objective of this report is to document the effectiveness of interracial hybridization in producing high-yielding disease-resistant lines of the race

Table 1. Characteristics of a few race Durango common bean cultivars and race Mesoamerica donor parents used in interracial hybridization at CIAT, Colombia

Identification	CIAT number	Growth habit[z]	Seed Color	Seed Size[y]	Observation
Race Durango cultivars[x]					
Bayo Madero	G 18446	III	Beige	Medium	Earliness
Bayo Zacatecas	G 18445	III	Beige	Medium	Drought tolerance
Guanajuato 31	G 2618	III	Beige	Medium	Positive general combining ability for yield
Pinto UI 114	G 4449	III	Pinto	Medium	Earliness
Zacaticano	G 2858	III	Pinto	Medium	Earliness
Race Mesoamerica donors[w]					
A 252	-	III	Cream striped	Small	Anthracnose resistance
BAT 561	-	III	Cream	Small	Drought tolerance
Carioca	G 4017	III	Cream striped	Small	Low soil fertility tolerance
XAN 87	-	II	Black	Small	Common bacterial blight resistance
XAN 112	-	II	Black	Small	Common bacterial blight resistance

[z] II, III = indeterminate erect and semiclimbing, respectively (Singh 1982a).
[y] Small = < 25 g/100-seed weight, and medium = 25–40 g/100-seed weight.
[x] All cultivars susceptible to bean common mosaic virus (BCMV) strain NL3.
[w] All lines possessed hypersensitive (*I* gene) resistance to BCMV.

Table 2. Pedigree of a few race Durango selected lines of common bean developed at CIAT, Colombia

Selected line	Cross code	Pedigree
A 321	BZ 1031	BAT 561 × (G 7474 × Guanajuato 31)
A 445	BZ 0268	Carioca × Guanajuato 31
A 797	MX 5299	(RAO 30 × A 59) × [Frijola × (A 252 × XAN 87)]
A 800	MX 7047	(MAM 13 × G 2923) × [A 321 × (BAT 85 × Zacaticano)]
MAM 27	MX 5196	(MAM 4 × Zacaticano) × (Bayo Madero × A 321)
MAM 41	MX 7027	A 375 × [Bayo Regional × (MAM 11 × G 3017)]
TAR 3	MX 5219	(A 329 × Bayo Madero) × [A 444 × (A 483 × XAN 112)]

Durango common bean, and discuss prospects for future genetic improvement.

MATERIALS AND METHODS

Characteristics of some frequently used parents from races Durango and Mesoamerica are summarized in Table 1. Table 2 contains a few examples of single and multiple crosses made to develop recombinant genotypes. An average of 1000-1500 F_2 seeds were produced for each population. Field facilities available at CIAT farms at Palmira (1000-m elevation, mean temperature 24°C, Mollisol soil), Quilichao (990-m elevation, mean temperature 24°C, Oxisol soil), and Popayán (1750-m elevation, mean temperature 18°C, Inceptisol soil) were used for evaluation and selection in hybrid populations, families, and advanced-generation lines. Often, two to three inoculations were made each growing season, with the mixture of local pathogen populations causing anthracnose at Popayán, and angular leaf spot and common bacterial blight at Quilichao. Visual mass selection for seed yield and/or resistance to diseases was practiced in F_2 and F_3. This was followed by single plant harvest in F_4 or F_5 and progeny tests in the subsequent generation. Lines uniform or true breeding for flower, growth habit, maturity, and seed characteristics were harvested in bulk. The F_6 or F_7 lines were screened for the dominant *I* gene resistance to BCMV in the screenhouse at CIAT-Palmira. Lines resistant to BCMV and uniform for desirable seed traits, maturity, and growth habit were yield-tested in replicated trials in F_7 or F_8. For further details on locations and evaluation and selection methods used, readers should refer to Singh et al. (1992a,c). Approximately 125 lines of mostly bayo, pinto, and ojo de cabra seed types were developed. A few black- and white-seeded lines were also selected.

Fifteen selected lines from the first cycle and five control cultivars—three from race Durango and one each from races Jalisco and Mesoamerica—were evaluated at three locations (Palmira, Quilichao, and Popayán, Colombia) for 3 yr (1989-1991). Control cultivars Alteño and Bayo Madero of race Durango were developed by the Mexican program of the Instituto Nacional de Investigaciones Forestales y Agropecuarias. Flor de Mayo is an indigenous race Jalisco cultivar grown in the Mexican highlands. Pinto UI 114 of race Durango was developed at the University of Idaho (USA). Singh et al. (1992c) provided details about the small-seeded race Mesoamerica control cultivar Carioca from Brazil. A randomized complete block design with three replications was used. Each plot consisted of four rows, 7 m long in the first 2 yr and 5 m long in the 3rd year. Between-row spacing at Popayán was 0.5 and at Palmira and Quilichao 0.6 m. A population of approximately 200 000 plants ha^{-1} was achieved at all sites. Data were recorded on a 1 to 9 scale (van Schoonhoven and Pastor Corrales 1987) for anthracnose at Popayán and for angular leaf spot and common bacterial blight at Quilichao. In addition, data were recorded for days to maturity. The two central rows, with head borders of 50 cm on either end removed, were harvested to measure yield and 100-seed weight. Values for both traits were adjusted to 14% moisture by weight. Data were tested for homogeneity of error variances before performing combined analysis of variance. Lines were considered fixed and locations and years random effects. Details of statistical analysis were similar to those reported earlier (Singh et al. 1992c). Also, the regression coefficient (Eberhart and Russell 1966) and coefficient of determination (r^2) were calculated for stability analysis for seed yield.

RESULTS AND DISCUSSION

Year, location, treatment, and all their interactions were significant for seed yield, yield d^{-1}, and days to maturity (Table 3). All variables except year were also significant for 100-seed weight. This indicates that differences among these factors occurred and that the performance of improved lines and their rank varied from location to location and from year to year within a location. This occurred even though the same three locations were used for evaluation and selection from the beginning. This may be somewhat expected as most of the Mexican highland germplasm belonging to the race Durango is photoperiod-sensitive and adapted to relatively cool temperatures at higher latitudes. Moreover, this germplasm was crossed with lowland tropical germplasm adapted to relatively warmer temperatures. Values for the regression coefficient for all selected lines (except MAM 27) and control cultivars were not significantly different from unity, which indicates an average response to variable environments (Table 4). Values for coefficient of determination that measures proportion of variation due to linear regression ranged

Table 3. Mean squares from analysis of variance of 20 common bean lines and control cultivars grown for 3 yr at three locations in Colombia

Source	df	Seed yield	Yield d^{-1}	Days to maturity	100-seed weight
Year (Y)	2	20 430 250**	9477.6**	955.7**	3.2
Location (L)	2	18 424 705**	2883.1**	11 196.4**	190.3**
Y × L	4	48 340 666**	2067.9**	1 802.8**	97.9**
Rep (Y × L)	18	498 520	72.8	8.8	7.0
Treatment (T)	19	1 310 814**	188.3**	303.2**	314.8**
Y × T	38	188 124**	31.7**	14.1**	7.1**
L × T	38	203 536**	47.2**	33.2**	9.6**
Y × L × T	76	183 644**	39.8**	9.1**	6.6**
Error	342	78 110	15.8	5.1	1.6

**Significant at $P = 0.01$.

Table 4. Mean values for seed yield and other traits of selected common bean lines of the race Durango and control cultivars evaluated at three locations for 3 yr (1989-1991) in Colombia

		Seed yield (kg ha^{-1})				Stability parameters[y]		Yield d^{-1}	Seed		
Identification[z]	Seed color	Palmira	Quilichao	Popayán	Mean	b	r^2	(kg ha^{-1})	weight (g)	Maturity (d)	Anthracnose score[x]
Selected lines											
A 321	Cream	2216	1540	2178	1978	1.02	0.94	24.6	27.5	75.8	1.9
A 445	Cream striped	1918	1573	1999	1830	0.84	0.87	21.4	26.6	78.9	1.3
A 797	Beige	1755	1391	2039	1728	0.90	0.97	20.2	32.0	80.3	1.7
A 800	Black	1912	1362	2232	1835	1.23	0.94	24.1	30.0	71.1	3.2
ARA 17	Pinto	1702	1440	1631	1591	0.88	0.91	19.4	30.8	77.4	1.6
CTC 2	Gray	1854	1555	2057	1822	1.07	0.94	22.7	27.0	76.9	1.9
MAM 13	Beige	1801	1302	2061	1721	1.02	0.92	21.2	29.0	75.9	4.6
MAM 27	Pinto	1887	1417	2569	1958	1.30*	0.93	24.3	31.6	75.6	2.7
MAM 29	Beige	1995	1587	2087	1890	0.86	0.86	22.7	35.1	79.5	1.7
MAM 30	Beige	1776	1398	1911	1695	0.94	0.91	20.7	30.1	78.9	1.8
MAM 32	Beige	1674	1426	2004	1701	0.94	0.94	20.2	33.6	79.8	1.7
MAM 36	Beige	1254	1118	1527	1300	0.94	0.91	15.2	27.4	80.8	1.8
MAM 38	Pink speckled	1906	1315	1902	1707	0.96	0.92	19.8	25.1	80.1	3.4
MAM 41	Cream	1936	1389	2030	1785	1.03	0.92	22.2	35.0	77.0	3.7
TAR 3	Cream	2283	1359	1990	1877	1.13	0.92	20.8	28.0	82.9	1.4
Controls											
Carioca	Cream striped	1932	1503	1798	1744	0.94	0.81	20.4	21.4	76.8	1.6
Alteño	Cream	1507	1056	1776	1446	0.98	0.97	17.8	25.0	74.9	1.9
Bayo Madero	Beige	1348	688	1648	1228	0.96	0.92	15.0	34.6	74.9	1.9
Flor de Mayo	Pink speckled	1261	1054	1828	1381	1.12	0.94	15.8	28.3	79.5	3.9
Pinto UI 114	Pinto	1414	1052	1698	1388	0.91	0.85	20.3	30.1	67.3	3.8
Mean		1767	1326	1948	1680			20.4	29.4	77.3	2.4
CV (%)		12.3	22.1	16.2	16.6			19.4	4.3	2.9	37.5
LSD (0.05)		202	271	293	149			2.2	0.7	1.3	0.8

[z]All selected lines and control cultivars were of indeterminate, prostrate, semi-climbing, type III growth habit.
[y]b = coefficient from regression of the genotype yield in an environment on the environmental index (i.e., mean of all entries in an environment minus overall mean across nine environments). r^2 = coefficient of determination.
[x]Recorded at Popayán on a 1 to 9 scale where 1 = immune and 9 = very susceptible.
*Significantly different from unity at $P = 0.05$.

between 0.81 and 0.97. Even so, it is likely that all desirable genes for abiotic and biotic factors conducive to stable performance and wide adaptation were probably not incorporated in the selected lines. More concerted, systematic, and alternative evaluation and selection strategies than the one used may be required if more stable performance and wide adaptation are desired. This could involve identification and hybridization among parents that are relatively insensitive to temperature and photoperiod, and inclusion of parents tolerant to other abiotic (drought, low soil fertility) and biotic factors (e.g., common bacterial blight and angular leaf spot). In addition, simultaneous incorporation and accumulation of desirable genes for multiple traits requires that segregating populations, families, and lines be systematically evaluated and selected at different sites in alternate generations (Singh et al. 1991b, 1992a).

Line A 321 had the highest yield, followed by MAM 27, MAM 29, TAR 3, A800, and A 445 (Table 4). More importantly, all but two lines (ARA 17 and MAM 36) significantly ($P < 0.05$) outyielded Alteño and Flor de Mayo, the highest-yielding control cultivars from races Durango and Jalisco, respectively. Only two lines (A 321 and MAM 27) significantly outyielded Carioca, the small-seeded, race Mesoamerica control cultivar. Although effects of locations and their interactions with treatments for seed yield were significant, the yield superiority of selected lines over race Durango control cultivars was generally expressed at both cool (Popayán) as well as warmer (Palmira and Quilichao) locations. Nonetheless, because cultivars of races Durango and Jalisco are better adapted in relatively cooler environments, seed yields at Popayán should provide better comparison between the control cultivars and selected lines. From Table 4 it can be seen that even at Popayán four selected lines (e.g., A 321, A 800, MAM 27, and MAM 29) out of 15 outyielded Alteño, the highest-yielding race Durango control cultivar. The fact that these selected lines had growth habit, maturity, and scores for anthracnose (the most prevalent disease at Popayán) similar to race Durango control cultivars further suggests that yield improvement of these selected lines was due to an increase in yield potential per se and not to other factors, such as resistance to diseases, change of growth habit, reduction in seed size, or delayed maturity. Apparently, selected lines possessed higher seed yield d^{-1} and hence were physiologically more efficient. Interestingly, three of these selected lines (e.g., A 321, MAM 27, and MAM 29) had an indigenous race Durango cultivar, Guanajuato 31 (G 2618), in their pedigree (Table 2). Thus, identification and use of more such parents in breeding common bean merits attention. Mean seed weights of Bayo Madero, MAM 29, and MAM 41 were the highest, and Carioca had the lowest seed weight (Table 4). Pinto UI 114 was the earliest-maturing line, whereas TAR 3 was the latest-maturing line.

The fact that all selected lines were derived from interracial populations (mostly Durango × Mesoamerica) suggests that different complementary gene systems controlling seed yield have evolved in these two races. This also suggests that considerable yield gains should be expected, at least in the initial selection cycles, from such interracial populations, as these results show. It was previously reported that use of Mexican highland germplasm helped improve yielding ability of small-seeded lines derived from these interracial populations (Singh and Gutiérrez 1990; Singh et al. 1989, 1991b). Had an early generation yield test (Singh et al. 1990; Singh 1992) been used instead of visual selection, along with selection for disease resistance, it is likely that many more high-yielding lines could also have been developed.

Breeders and geneticists using mostly biparental or single interracial crosses may face serious difficulties in identifying and selecting high-yielding recombinant genotypes possessing desirable seed types (e.g., size, color, shape) and plant characteristics. This can occur, although plant characteristics usually have high heritability (Ghaderi and

Adams 1981; Nienhuis and Singh 1986, 1988b; Singh et al. 1991c), and breeders use relatively large (> 1000) F_2 populations. Thus, three-way crosses and modified double crosses (Table 2; Singh 1982b), some form of backcrossing (Sullivan and Bliss 1983; Haghighi and Ascher 1988; Sullivan 1988), or recurrent selection (Kelly and Adams 1987) are required to increase the genetic contribution from the race Durango, without losing desirable genes from the donor parents. Alternatively, parents showing affinity for desired seed and plant traits of race Durango, but belonging to different races, could be used in crosses with the race Durango. For example, small-seeded tropical reds belonging to the race Mesoamerica could be used to cross with pink and red Mexican groups of the race Durango. Similarly, small-seeded white navy and cream ('mulatinho') germplasm of the race Mesoamerica could be hybridized with great northern and pinto beans (Table 2), respectively, of the race Durango.

Mean disease scores for anthracnose at Popayán were generally low for most selected lines (Table 4) and control cultivars. Common bean germplasm from races Durango and Jalisco is usually resistant to the pathogen populations of anthracnose at Popayán. Thus, the level of resistance to anthracnose was either maintained or increased through the selection process in interracial populations. On the other hand, selection for resistance to angular leaf spot and common bacterial blight was not as effective as that for anthracnose because most of the lines had either moderate resistance or susceptibility to these two diseases (data not shown). This could be due to the fact that not all populations contained parents resistant to these diseases. Also, a relatively larger number of germplasm possessing very high levels of resistance or immunity to anthracnose is often available in common bean (Schwartz et al. 1982). This resistance is controlled by qualitative or major genes (Cárdenas et al. 1964; Muhalet et al. 1981; Peloso et al. 1989), and field and greenhouse screening techniques are reliable. Moreover, the temperature and humidity prevailing at Popayán are highly conducive to anthracnose development (Singh et al. 1991b). On the other hand, levels of resistance in common bean for angular leaf spot and common bacterial blight are not as high as those for anthracnose. Also, field screening for resistance to angular leaf spot and common bacterial blight can be problematic in spite of repeated inoculation with local pathogen populations. New and higher levels of resistance are available for common bacterial blight from within common bean (Rava et al. 1987; Silva et al. 1989) and from *P. acutifolius* (McElroy 1985; Drijfhout and Blok 1987; Michaels 1992) and *P. coccineus* (Park and Dhanvantari 1987), and should be used. In addition, field screening must be combined with greenhouse evaluation to identify and eliminate potential escapes.

Few improved lines of the race Durango possess the dominant, hypersensitive *I* gene conditioning resistance to BCMV. Because all lines developed in our program and used in this study carry this resistance gene, these lines should serve as valuable germplasm for other programs where the race Durango types are grown. It should be easier to transfer the *I* gene into local cultivars from these bred lines than from the original sources from the races Mesoamerica and Nueva Granada. However, researchers interested in using these lines either as parents in hybridization programs or directly as potential new cultivars must evaluate them adequately under local conditions for adaptation and the presence of other traits.

These and other results (Bliss 1985; Kelly and Adams 1987; Singh et al. 1989; Morales and Singh 1993) should justify and encourage the use of interracial populations by common bean researchers for improvement of seed yield and other agronomic traits, including plant architecture, tolerance to low soil fertility and water deficit, and resistance to insects and, especially, diseases such as rust, anthracnose, and angular leaf spot caused by highly variable pathogen populations. Nonetheless, for adequate and efficient use of interracial genetic variability, information on combining ability of parents, and alternative recombination and selection methods, may be essential.

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